Passive Droop Control in a Decentralized 12V DC Energy Access Microgrid with Lead Acid Batteries

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Presentation at MES 2015 Conference, April 23rd 2015

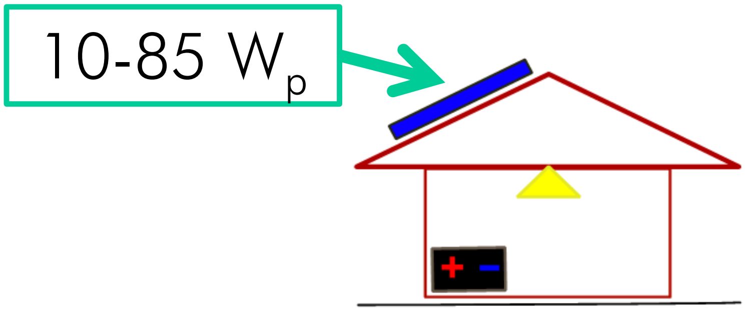
A good site for a centralized structure?

Outline

1. Motivation: Swarm Electrification
2. Background: Droop Control
3. Approach Taken: Passive Droop
4. Microgrid n=4
5. Microgrid n=8
6. Summary

A good site for a centralized structure?

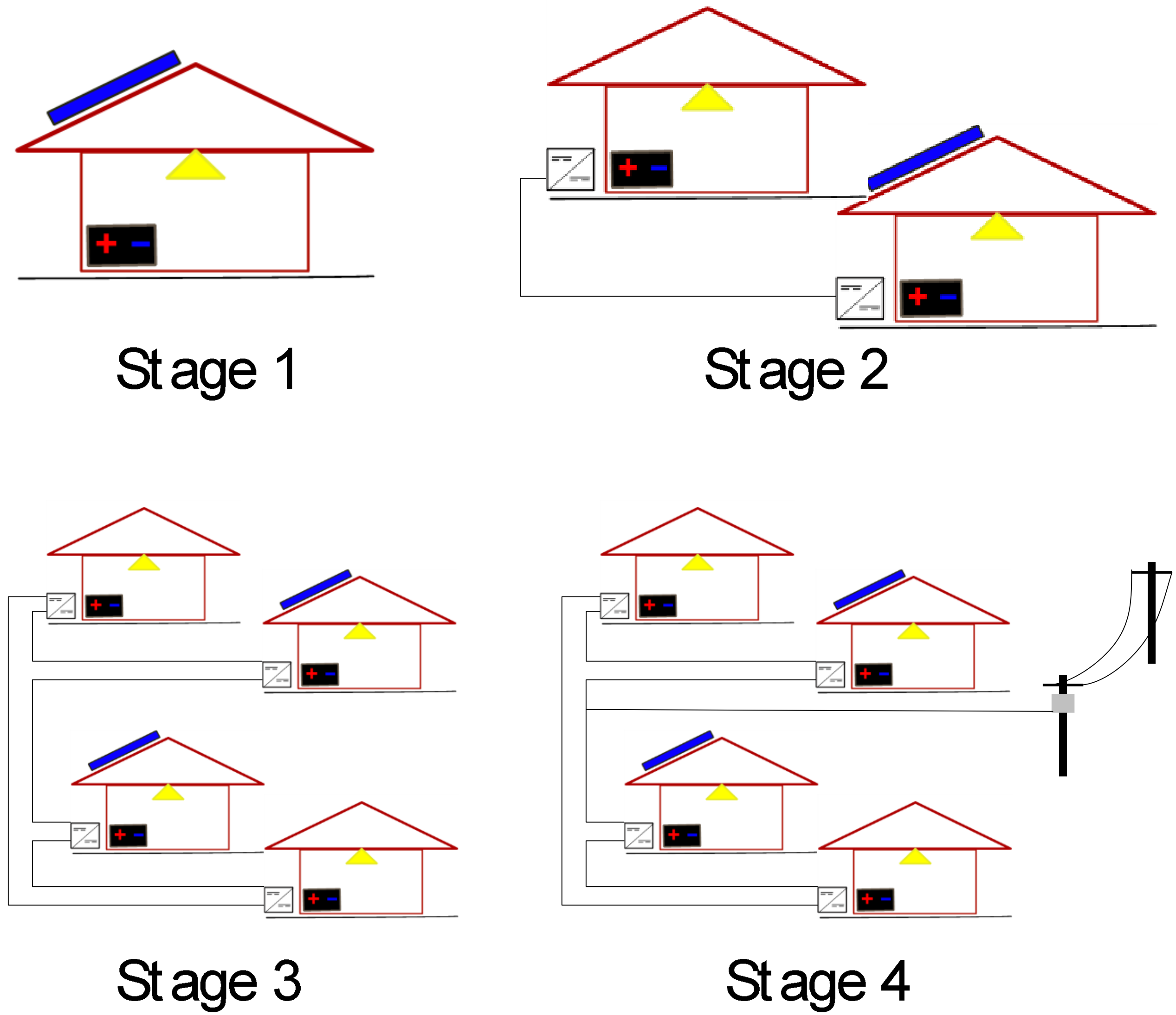
Proposed bottom-up concept



Stage 1

> 3.5 million *Solar Home Systems* (SHS) installed in Bangladesh alone (IDCOL 2015)

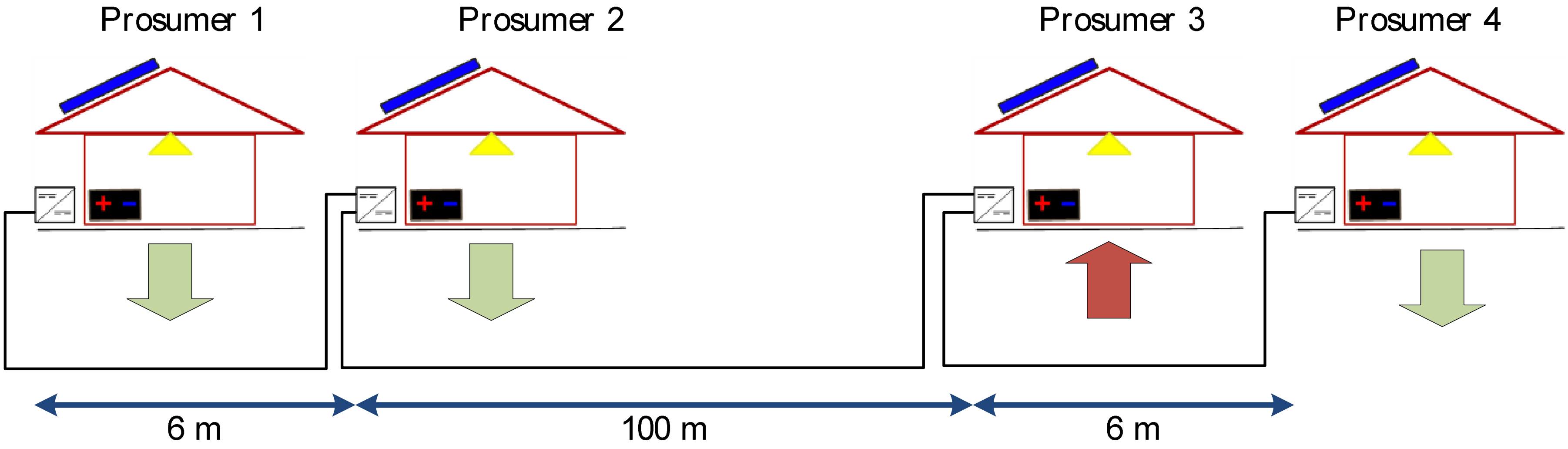
Proposed bottom-up concept



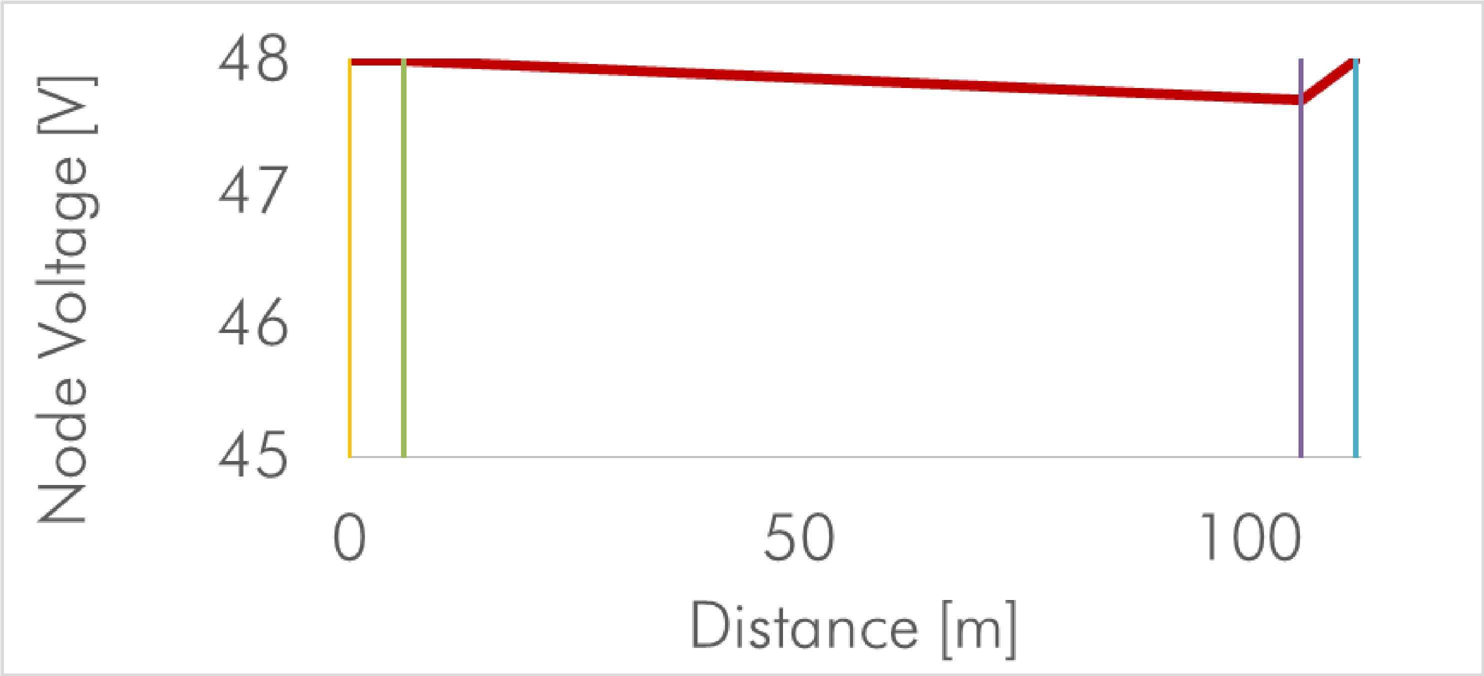
Control

1. Control is required to assure proper power flow
2. Criteria to evaluate schemes (Anand, Fernandes, & Guerrero, 2013):
   1. Voltage regulation
   2. Load sharing
   3. Modularity
3. General schemes:
   1. Centralized (vulnerable due to explicit communication link)
   2. Decentralized (Very modular, less accurate)
   3. Distributed (Mix) and hybrid versions (low level communication)

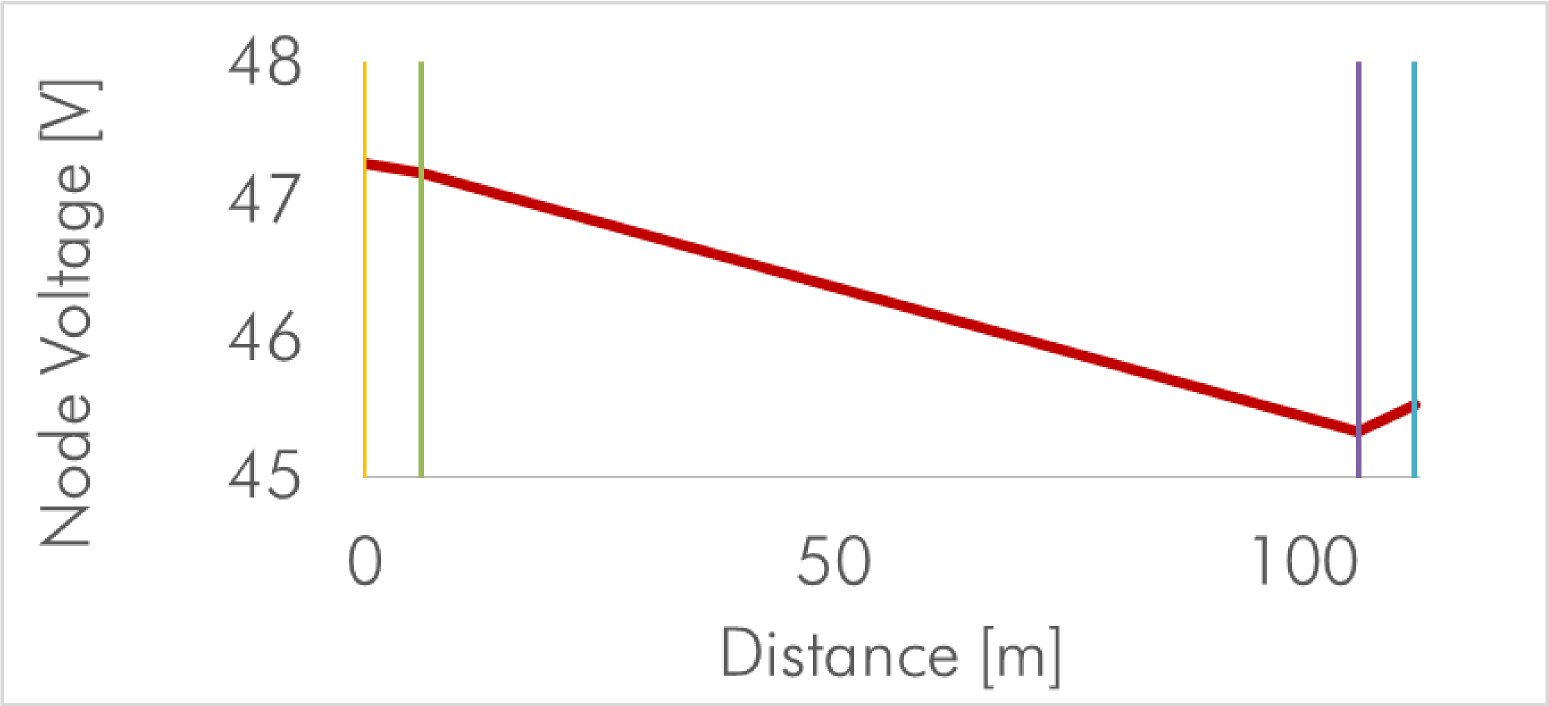
Working Principle of Droop Control



Working Principle of Droop Control

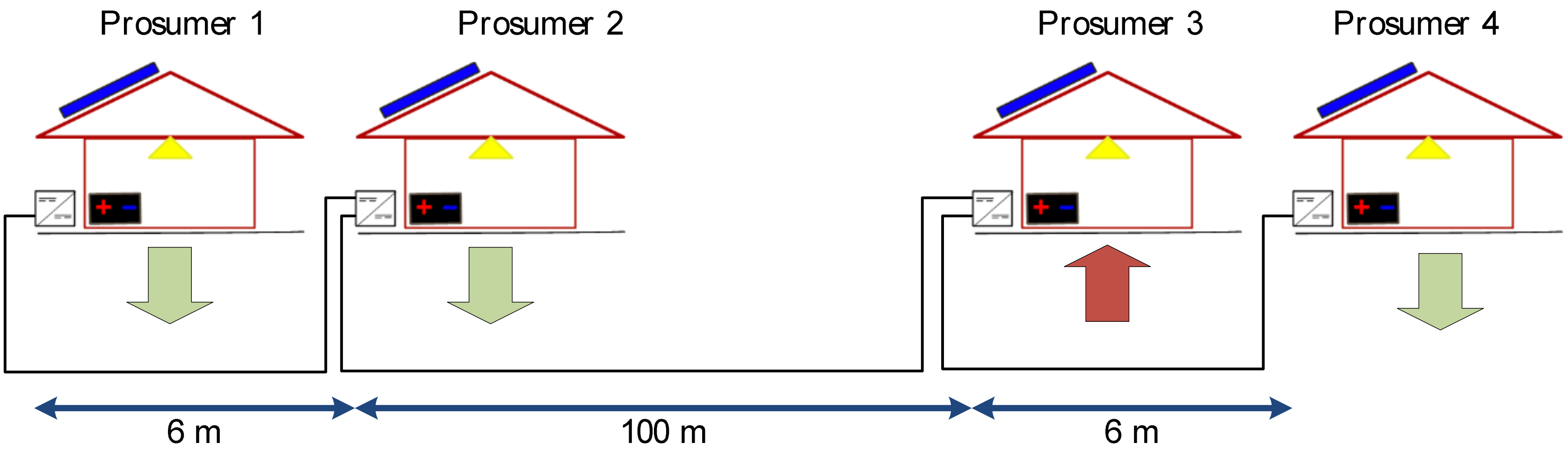


Name Mode	Prosumer 1 Feeding-in	Prosumer 2 Feeding-in	Prosumer 3 Consuming	Prosumer 4 Feeding-in
V_{grid} [V]	48	48	47.7	48
$I_{to\text{-}grid}$[A]	0	0.11	-2	1.89



Name Mode	Prosumer 1 Feeding-in	Prosumer 2 Feeding-in	Prosumer 3 Consuming	Prosumer 4 Feeding-in
V_{grid} [V]	47.3	47.2	45.3	45.5
$I_{to\text{-}grid}$[A]	0.37	0.39	-2	1.24

Working Principle of Droop Control



Name	Prosumer 1	Prosumer 2	Prosumer 3	Prosumer 4
Mode	Feeding-in	Feeding-in	Consuming	Feeding-in
V_{grid} [V]	48	48	47.7	48
$I_{to\text{-}grid}$[A]	0	0.11	-2	1.89
V_{grid} [V]	47.27	47.21	45.33	45.52
$I_{to\text{-}grid}$[A]	0.37	0.39	-2	1.241

Passive Droop Control

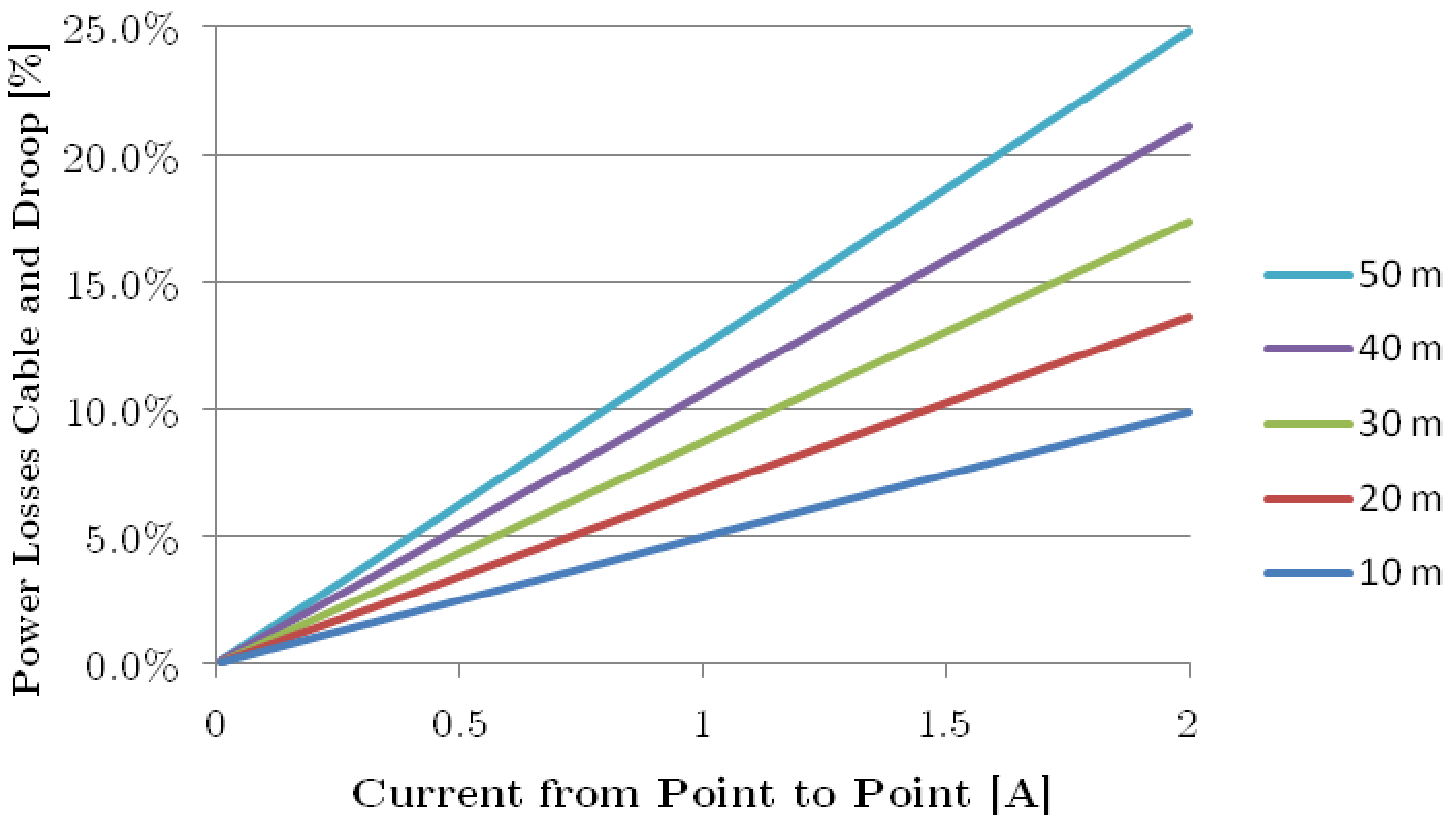
Active Droop Control

1. Enables a Dynamic Control of the Output Voltage
2. Can be linked with a Step-Up /Step-Down Process for higher voltages
3. Higher Voltage can reduce cable losses, but comes with DC/DC conversion losses

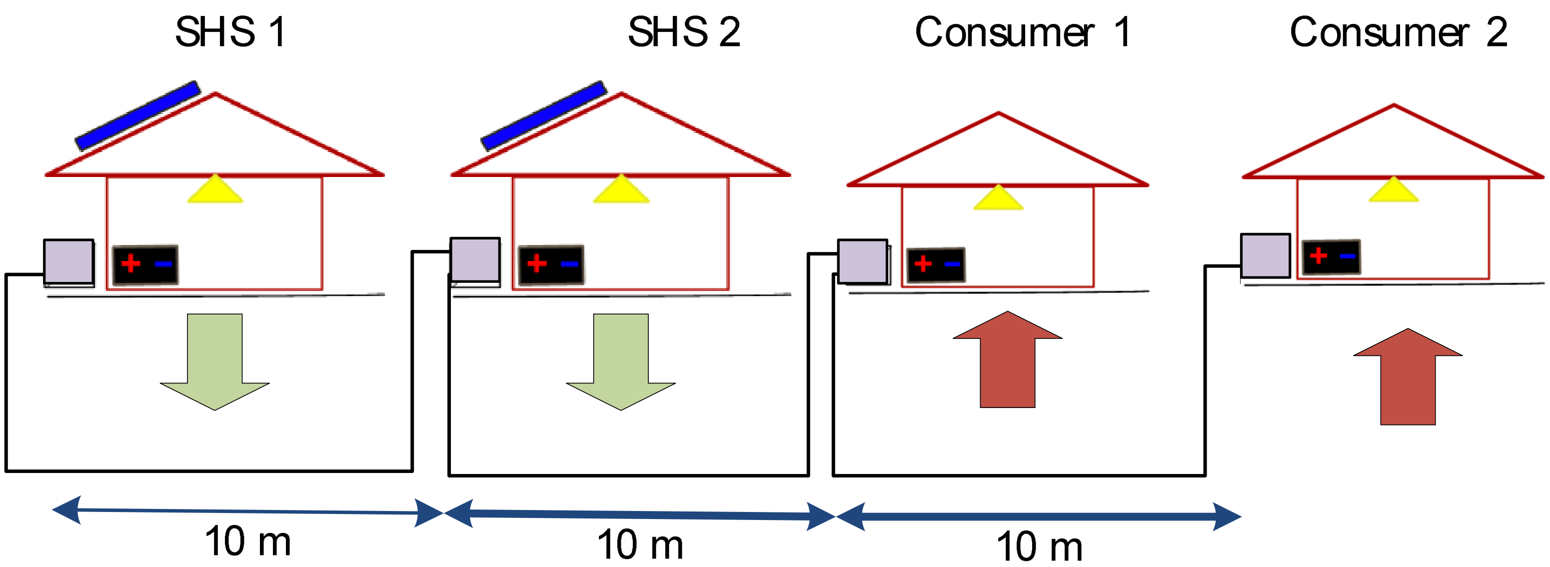
Passive Droop Control

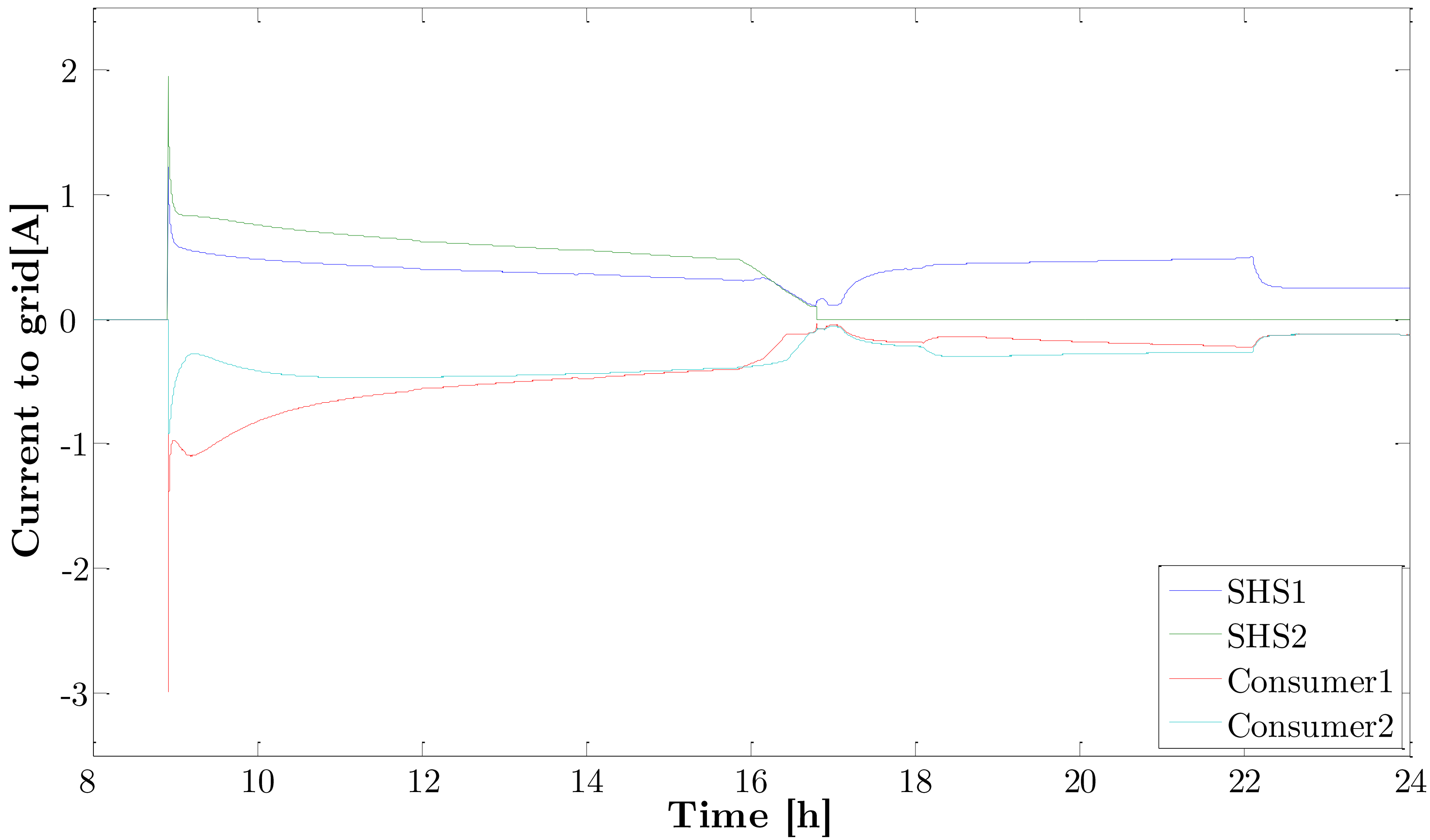
1. Can easily be applied without power electronics
2. Very limited range for dynamics
3. Internal Resistance of components can be used
4. Needs to be carefully sized to for safe operation over lifetime

Losses in Passive Droop Control



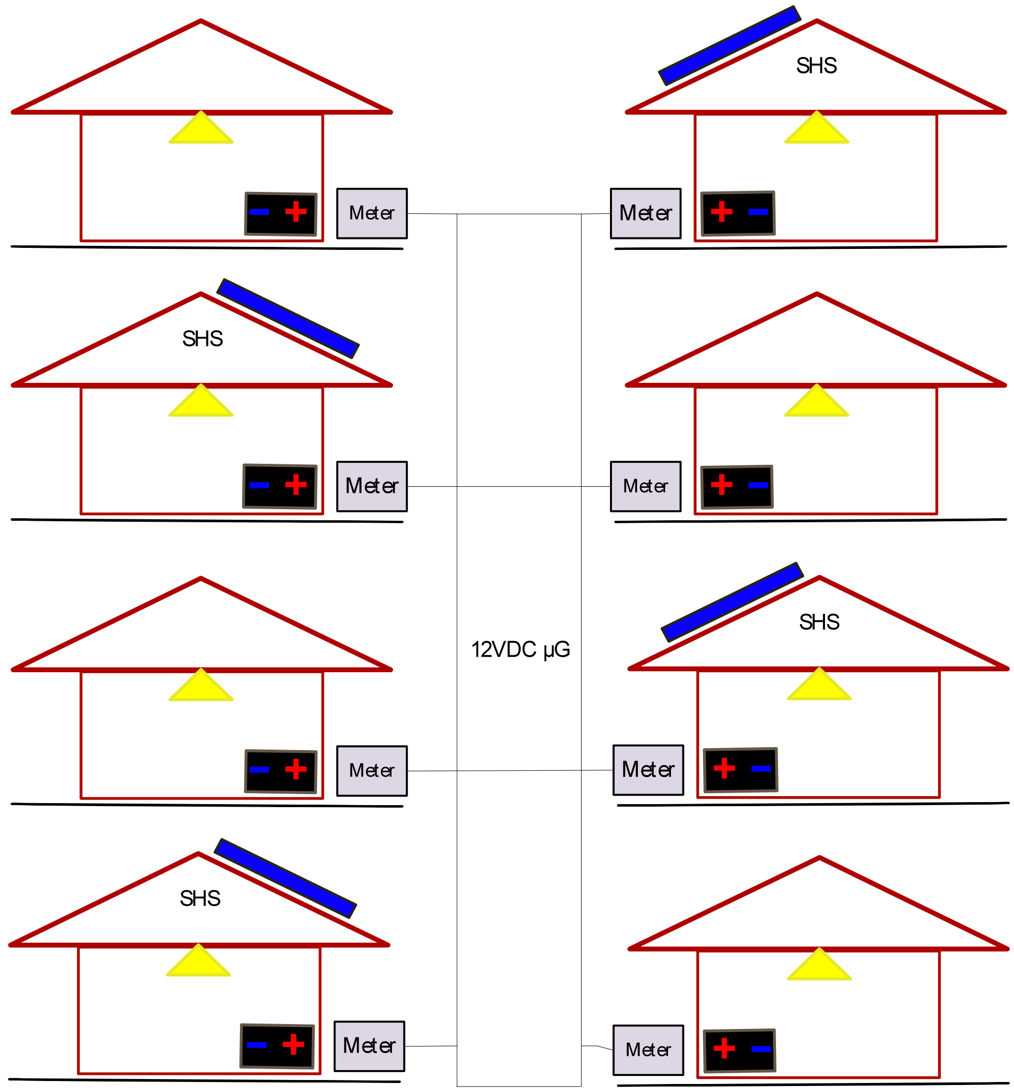
Passive Droop





Current to grid[A]
2
1
0
-1
-2
-3
8
10
12
14
16
18
20
22
24
Time [h]
SHS1
SHS2
Consumer1
Consumer2

Microgrid, n=8



Results- Passive Droop

	SHS				Consumer			
Inputs								
Battery Size[Ah]	100	100	100	100	25	25	25	25
SOC start [%]	80	80	80	80	30	30	30	30
Daily Supply [Wh]	207	207	207	207	0	0	0	0
Daily Load [Wh]	162	162	162	162	40	40	40	40
Results								
Feed-in [Wh]	75	76	79	74	0	0	0	0
Take-out[Wh]	0	0	0	0	75	75	75	75
SOC end [%]	77	77	77	77	41	41	41	41

Summary

1. Motivation: Swarm Electrification
2. Droop control is a promising control concept
3. Passive Droop Control can implemented without the need for power electronic components
4. Power losses at 12V level are acceptable for low currents
5. Next: lab-testing

Virtual Session: DC Microgrids in Practice

1. **Bruce Nordman**, Environmental Energy Technologies Division Lawrence Berkeley National Laboratory
2. **Fabio De Pascale**, CEO Devergy
3. **Timothy Walsh**, Solar Energy Research Institute Of Singapore (SERIS)
4. **Shahriar Chowdhury**; Director, Centre for Energy Research, United International University Dhaka

Date: Friday, April 24th 2015
Time: 1.30 pm local time (IST)
www.gotowebinar.com

GoToWebinar ID: 125-561-827


Thank you very much!

Matlab Simulink Screenshot